BULK RETAIL STORE FIRE
Tempe, AZ
March 19, 1998

NFPA
INTERNATIONAL

FIRE INVESTIGATIONS

NATIONAL FIRE PROTECTION ASSOCIATION

1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101 USA
Telephone: 1-617-984-7263 E-mail: investigations@nfpa.org

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MARCH 19, 1998

Prepared by

ED COMEAU
CHIEF FIRE INVESTIGATOR
NATIONAL FIRE PROTECTION ASSOCIATION

ROBERT DUVAL
FIRE INVESTIGATOR
NATIONAL FIRE PROTECTION ASSOCIATION

CHRISTIAN DUBAY
FIRE PROTECTION ENGINEER
NATIONAL FIRE PROTECTION ASSOCIATION

ABSTRACT

A fire occurred in an occupied bulk retail store in Tempe, Arizona on Thursday, March 19, 1998, at approximately 4:00 p.m. At the time of the fire 110 people were estimated to be in the store. There were no injuries or fatalities as a result of this fire.

The building in which the fire occurred was a sprinklered, bulk retail store that sold general home improvement merchandise. The building was constructed in 1988.

Investigators from the Tempe Fire Department determined that the area of origin was in a rack that contained lawn furniture seat cushions. The cause was determined to be incendiary and was started by someone using a point-and-click type of lighter to ignite the seat cushions.

According to eyewitness testimony, when the fire was first observed it was located approximately chest height on one side of a 12 ft (3.7 m) high double-row rack. There was an additional 3 ft (0.9 m) of storage on the top level that created a total height of 15 ft (4.6 m). The size of the fire at that time was characterized as being as big as a computer monitor. Within a very short time, the fire had extended vertically along both the outside face of the rack and within the flue longitudinal space the full height of the rack.

A series of telephone calls were made to the Phoenix Fire Department Alarm Room, which dispatches for the Tempe Fire Department. One of the first calls was by an off-duty Phoenix fire fighter, who suggested that an immediate first alarm assignment be dispatched because of the severity of the fire. Other calls also reported a serious fire.

The first company to arrive was Phoenix Engine 38, which was located 1.2 miles (1.9 km) away. As soon as they left the station they could see a large column of smoke coming from the area. Upon arrival, they immediately made entry in through the northeast door, advancing a handline. They reported that smoke had filled the building from floor to ceiling and that visibility was zero. The sprinklers had activated by this time, and the fire fighters were inundated with water as they made entry, advancing with an 1-3/4 in. hose line. The officer reported that they had to climb over debris in the aisles to reach the seat of the fires. Not until they came up to the fire was it visible, due to the heavy smoke conditions.

A ladder company was assigned to ventilate the roof. When they reached the area over the fire, they reported that one skylight had burned through and that three automatic roof vents had opened. They proceeded to open approximately 42 more, either by popping them open with an axe or sawing through the fiberglass panels.

Eventually, 66 sprinklers were activated over an area of 5,082 ft^2 (472 m^2). Fire damage from flame impingement was limited to 1,500 ft^2 (139 m^2). The fire destroyed product in the rack of origin for a length of 32 ft (10 m) and for the full height of the rack. It also spread to the other side of the double-row rack, destroying product over a length of 32 ft and for the full height of the rack.

The fire spread across a 10 ft (3 m) aisle and ignited the commodity being stored on the shelves in that rack. This commodity was comprised of barbecue gas grill products wrapped in plastic or cardboard material.

The fire impinged directly on the combustible roof trusses and the combustible roof panels. Two trusses and a number of roof panels had to be replaced following the fire. A third truss had to be repaired.

The building in which the fire occurred was a one-story, reinforced masonry structure measuring 400 ft x 250 ft (122 m x 76 m) and ranged from 24 ft to 29 ft (7.3 m to 8.8 m) high. This resulted in an area of 100,000 ft^2 (9,290 m^2). The roof was supported by lightweight, parallel chord, wood trusses measuring 4 ft (1.2 m) deep. The trusses were comprised of 2 in. x 4 in. wood members joined by metal gusset plates. The roof assembly consisted of 4 ft x 8 ft (1.2 m x 2.4 m) panels constructed of 1/2 in. (13 mm) plywood resting on 2 in. x 6 in. wooden supports.

The building was equipped with three ceiling level, wet sprinkler systems. The systems were designed to provide water at a density of 0.495 gpm/ft^2 over 2,000 ft^2 (20.2 (L/min)/m^2 over 185.8 m^2) and were designed to protect a Class IV commodity for a maximum storage height of 20 ft (6 m). The maximum number of sprinklers that it was designed for was 29 sprinklers operating simultaneously. The upright sprinklers were equipped with 286° F (141° C) fusible elements and with 17/32 in. (13 mm) diameter orifices. The building was divided into three zones, and was supplied with water through an 8 in. (203 mm) municipal connection. The control valves and flow switches were supervised by the building fire alarm system. The only in-rack sprinkler system was located in a section of the paint aisle that was not affected by the fire.

The building was equipped with a fire alarm system that was monitored by an off-premises monitoring company. The alarm system monitored the flow switches on the three risers and the tamper switches on the control valves. There were no manual pull stations or audible alarm devices. The only visual warning devices were located in the bathrooms.

A series of draft curtains were located throughout the building. They were constructed of sheet metal and measured 78 in. (2,000 mm) in depth. One draft curtain was located directly over the aisle where the fire occurred.

There were a total of 93 skylights and 29 automatic, thermal activated roof vents, each measuring 4 ft x 8 ft (1.2 m by 2.4 m). The roof vents were equipped with 165° F (74° C) fusible links.

The rack in the area of origin measured 12 ft high (3.7 m), 32 ft long (9.8 m) and 2.5 ft deep (0.76 m). An additional 3 ft (0.9 m) of storage on the top level of the rack resulted in a total storage height of 15 ft (4.6 m). Immediately adjacent to this rack was another rack measuring 4.5 ft (1.4 m) deep. The two racks were separated by a longitudinal flue space, creating a double-row rack configuration.

The double-row racks were separated by a longitudinal flue space which varied in measurement from approximately 0 to 6 in. (0 mm to 150 mm). The transverse flue spaces measured three in. in width and were spaced approximately 8 ft (2.4 m) apart. Due to the damage in the area of origin, it was not possible to determine if the longitudinal flue spaces were blocked by product or kept open. However, it was observed throughout the store that it was very common to have the longitudinal flue space obstructed by product. There did not appear to be any provisions made to keep this from occurring.

Shelving was a combination of either solid sheets of plywood that measured 4 ft x 8 ft (1.2 m x 2.4 m) by 3/4 in. (19 mm) thick, or 2 in. x 6 in. wooden slats that were installed next to each other, creating a solid shelf without spacing between the individual slats.

The area where the fire occurred contained merchandise such as seat cushions, patio umbrellas, and plastic lawn chairs. Merchandise at the lower levels was either loosely packed or within cartons that had been opened to allow customer access to the product. Merchandise on the upper levels was on pallets that had been shrink-wrapped around four sides. The product on the adjacent rack was comprised of grass trimmers, plastic gasoline can and other outdoor-related products. Much of the material would be classified as a Group A plastic, both expanded and unexpanded, as defined by NFPA 231C, *Standard for Rack Storage of Materials.*

During the investigation, it was noticed that the foil facing on the roof-level fiberglass insulation (also known as reflective insulation) had become dislodged. In some areas, this foil was either draped over sprinklers or hanging in such a way as to obstruct the flow of water from the sprinkler.

Based on the NFPA's investigation and analysis of this fire, the following significant factors were considered as having contributed to the loss of property in this incident:

Fire ignition through arson	
Ceiling sprinkler density	At the time that the building had been constructed, the sprinkler system was designed for Class IV commodities. However, at the time of the fire, the commodity in the area of origin was predominantly Group A expanded and unexpanded plastics. This commodity would have required a greater ceiling sprinkler density.
Flue spaces	Inadequate transverse flue spaces within the racks.
Draft curtains	Due to the activation profile of the sprinklers, it would appear that the draft curtains effected which sprinklers opened. The impact that the draft curtains had is a case for further study to determine the value of draft curtains in a fire protection scheme.
Fusible links on the ceiling vents	Since the temperature rating on the ceiling vent links was below those of the sprinkler system, the links could possibly have fused prior to sprinkler activation. If the ceiling vents then opened, they would have allowed for the release of heat that could have impacted upon the sprinkler activation profile.
Obstructed sprinkler spray patterns	The foil on the ceiling insulation became dislodged in many areas during the fire and obstructed the spray patterns on the sprinklers. In one case, the foil was draped completely over a sprinkler.

This is the third fire that NFPA has investigated in a bulk mercantile retail building in three years. The other two, one in Quincy, Massachusetts, and the other in Albany, Georgia, involved pool chemicals, which greatly accelerated the fire. In this case, however, the fire was fueled by conventional fuel loads, and overwhelmed the inadequately designed sprinkler system, destroying 96 linear ft (29 m) of racks and product, and causing six million dollars in damage.

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I. INTRODUCTION

The National Fire Protection Association (NFPA) investigated the Tempe, Arizona bulk retail store fire in order to document and analyze significant factors that resulted in the loss of property.

The investigation was conducted by the NFPA as part of its on-going program to investigate technically significant incidents. The NFPA's Fire Investigations Department documents and analyzes incident details so that it may report lessons learned for life-safety and property loss prevention purposes.

The NFPA became aware of the fire on March 22, 1998, one day after it occurred. Edward Comeau, Chief Fire Investigator, and Robert Duval, Fire Investigator, of the NFPA Fire Investigations Department, and Christian Dubay, Fire Protection Engineer, of the Systems and Applications Engineering Department, traveled to Tempe, Arizona, to perform a study of the incident. That five day, on-site study and subsequent analysis of the event were the basis for this report. Entry to the fire scene and data collection activities were made possible through the cooperation of the Tempe Fire Department.

In addition to the physical scene investigation conducted by NFPA's three investigators, the incident was extensively documented through interviews with the first due fire companies, command officers, investigators, and inspectors. Structural and sprinkler plans were also obtained and reviewed. The audio tapes of the radio traffic and telephone calls were reviewed by the investigators as well as the computerized incident history. All of this information was used in preparing this document.

This report is another of the NFPA's studies of fires having particular important educational or technical interest. All information and details regarding fire safety conditions are based on the best available data and observations made during the on-site data collection phase and on any additional information provided during the report development process. It is not the NFPA's intention that this report pass judgment on, or fix liability for, the loss of property resulting from the fire. Rather, the NFPA intends that its report present the findings of the NFPA data collection and analysis effort, and highlight factors that contributed to the loss of property.

Current NFPA codes and standards were used as criteria for this analysis so that conditions at the building on the day of the fire could be compared with state-of-the-art fire protection practices. It is recognized, however, that these codes and standards may not have been in effect during construction or operation of the Tempe bulk retail store. The NFPA has not analyzed the building regarding its compliance with the codes and standards that were in existence when it was built or during its operation.

The cooperation and assistance of Chief Cliff Jones and the staff of the Tempe Fire Department is greatly appreciated.

II. BACKGROUND

Occupancy Classification

Per *NFPA 101®, Life Safety Code®*, 1997 edition, this building would have been classified as an existing bulk merchandising retail building.

The 1997 edition of NFPA 101 is the first edition that recognized this specific type of mercantile occupancy.

Applicable Codes and Enforcement

At the time of construction, Tempe was enforcing the 1985 edition of the Uniform Building Code.

The Building

The building was constructed in 1988 and was located in a plaza with other stores. It was a one story structure measuring 400 ft long (122 m), 250 ft wide (76.2 m) and 24 ft to 29 ft high (7.3 m to 8.8 m). This resulted in an area of 100,000 ft^2 (9,290 m^2). The wall construction was reinforced masonry block that measured 8 in. x 12 in. x 16 in. (203 mm x 305 mm x 406 mm). The roof was supported by parallel chord, wood trusses measuring 4 ft (1.2 m) deep that were composed of 2 in. x 4 in. wood members joined by metal gusset plates. The top and bottom chords, and the webs were 2 in. x 4 in. wood members, that created chords that measured 4 in. by 4 in. (nominal). The trusses were spaced 8 ft apart (2.4 m) and ran in the east-west direction.

The combustible roof assembly was comprised of wood panels. They were composed of 1/2 in. thick (13 mm) plywood that measured 4 ft x 8 ft (1.2 m x 2.4 m) that was mounted on 2 in. x 6 in. wooden supports. These assemblies were then, in turn, supported by wooden truss assemblies.

The roof covering was built-up roofing material that measured 1/2 in. (13 mm) thick and was comprised of four layers of material.

The underside of the roof deck had 6 in. (152 mm) thick, foil-backed fiberglass insulation batts that filled the joist channels created by the 2 in. x 6 in. wood joists. The insulation was stapled to the bottom of the wood roof joists.

Vertical structural support was provided by steel columns that measured 7 in. by 7 in. (178 mm by 178 mm). The columns were spaced 40 ft x 48 ft (12 m x 15 m). Sidewall sprinklers were provided at the columns.

A Type III (200) structure will have a 2-hour fire rating for the exterior bearing walls (first digit), a 0-hour fire rating for structural frame or columns and girders supporting loads for more than one story (second digit), and a 0-hour fire rating for the upper story assembly (third digit).

The building most closely resembled Type III (200) construction according to the criteria in NFPA 220, *Standard on Types of Building Construction*, 1995 edition.

Egress

There were a total of 14 exit doors that led from the building to the exterior. There were a combination of door types, which include power-operated doors, and manually operated, side-hinged doors. The combined width of these doors was 1,344 in. (34 m)

Rack Assemblies

The racks were built of metal vertical and horizontal members. The vertical supports measured 3 in. x 3 in. (76 mm x 76 mm). Horizontal supports measured 2 in. x 2 in. (51 mm x 51 mm). The racks were anchored in some locations and simply rested on the floor in other locations. **(See Figure 1)**

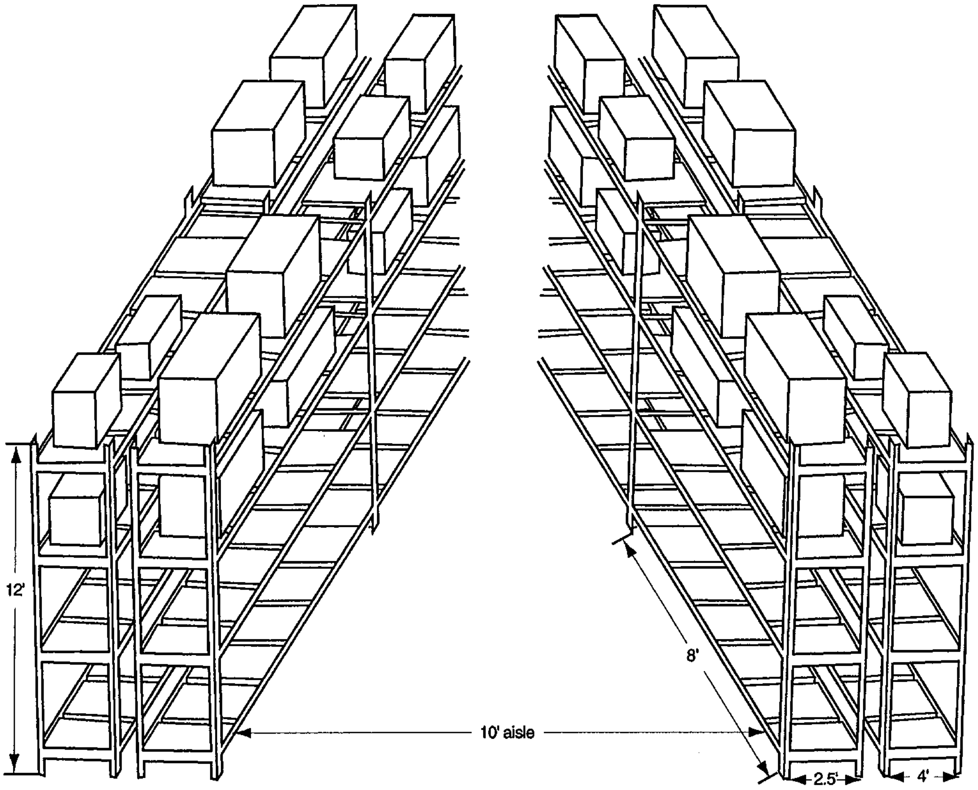


Figure 1. View of the aisle where the fire originated. The double row racks measured 12 ft high (3.7 m), with an additional 3 ft (0.9 m) of storage on top, resulting in a total storage height of 15 ft (4.6 m).

Shelving on the racks was comprised of two materials. Slats measuring 2 in. x 6 in. were placed on the horizontal supports were one common method. These slats would be placed immediately adjacent to one another, creating a solid shelf. (**See Photo 1**)

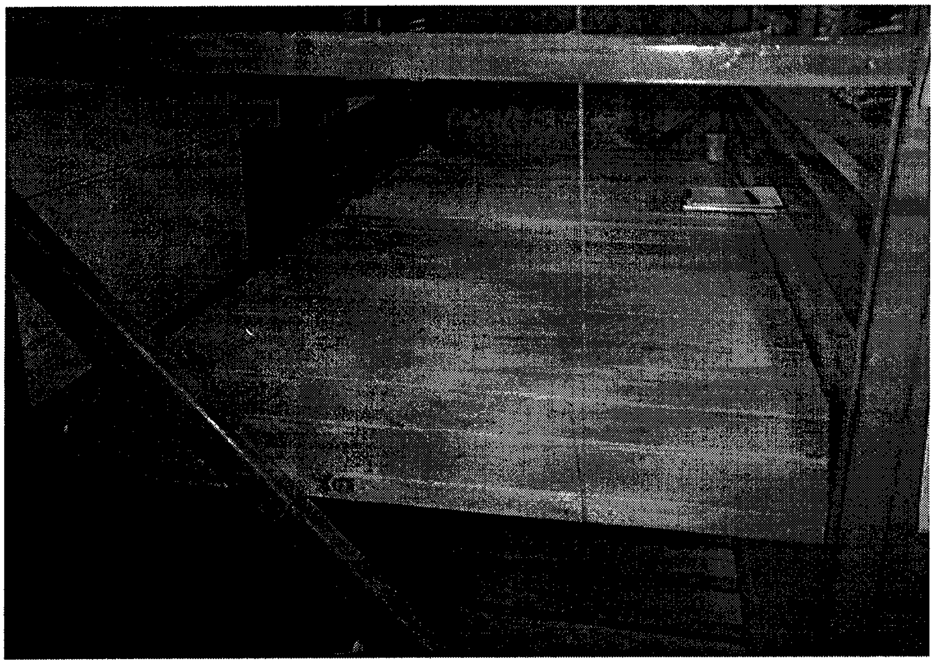
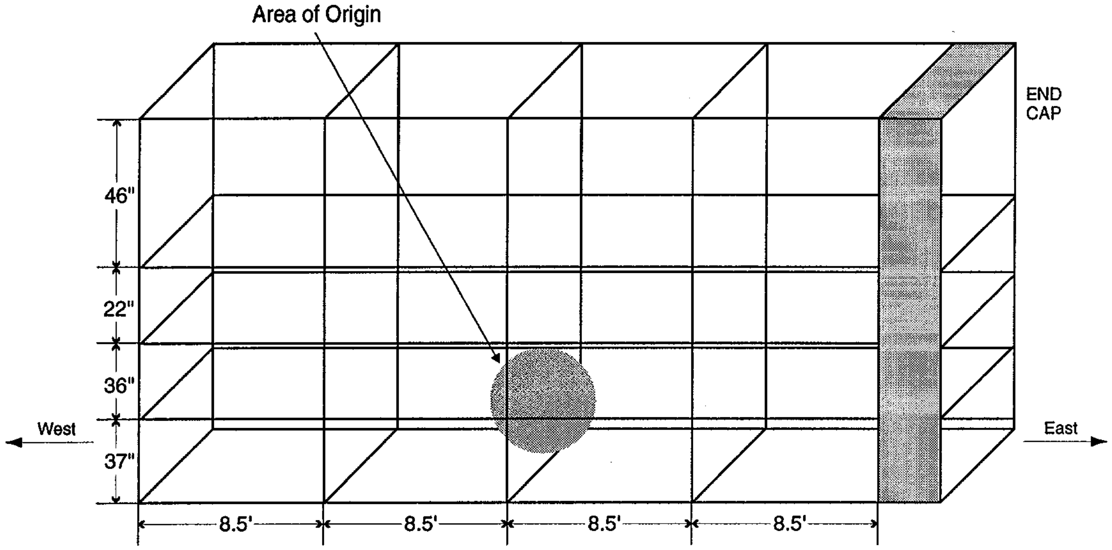


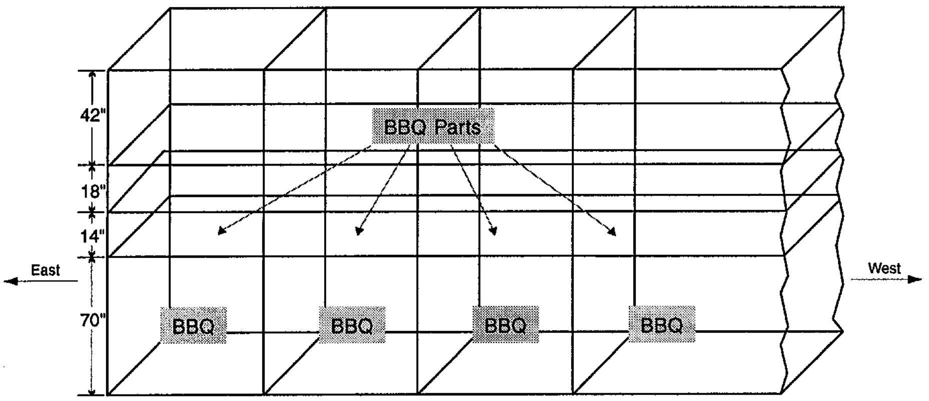
Photo 1. Wooden 2 in. x 6 in. slats were used extensively throughout the store for shelving material. In a vast majority of the racks the slats were placed immediately adjacent to one another, creating a solid surface on the racks.

Figure 2. The rack of origin was made of bays that measured 8.5 feet in length and had varying heights for each level. An end cap contained merchandise.



Another material that would be frequently used was sheets of plywood measuring 3/4 in. (19 mm) thick. In some cases, both the slats and the plywood together were used to provide shelving.

Figure 3. Elevation view of the rack located to the south of the rack of origin. This rack was separated from the rack of origin by a ten-foot aisle.



In the rack containing the barbecue grills, the rear vertical wall of the rack was comprised of a sheet of plywood.

Flue Spaces

The transverse flues in the racks measured 3 in. wide. This spacing was created by the vertical support member of the rack.

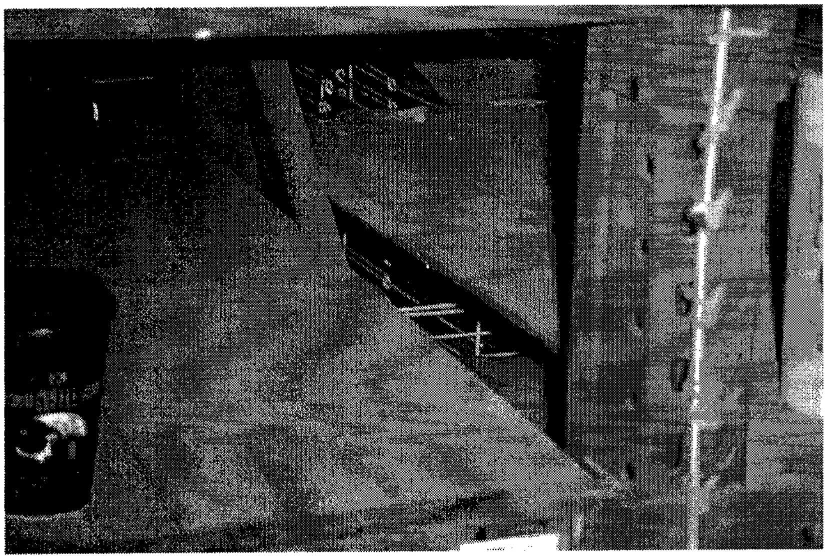


Photo 2. Transverse flue spaces were created by the structural support members of the racks. These flues measured 3 in. wide (76 mm).

Roof Vents

There were 29 automatic ceiling vents located throughout the store. These vents were equipped with 165° F (74° C) fusible links. They were designed to operate automatically during a fire. **(See Photo 3)** During the course of the investigation it was noticed that a number of the roof vents had caulking applied along the edges of the exterior of the translucent panel to create a weather-tight seal.

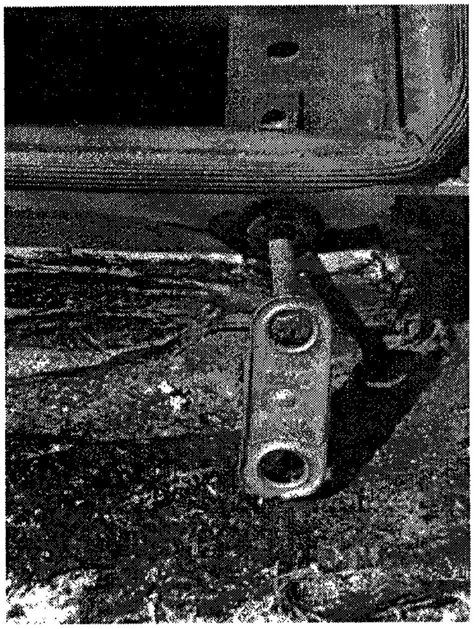


Photo 3. The fusible links on the automatic roof vents were rated at 165 degrees F (74 degrees C).

Skylights

In addition to the ceiling vents the roof had 93 skylights. These skylights were similar in design to the ceiling vents, but were not designed to open. They measured 4 ft x 8 ft (1.2 m x 2.4 m) and were comprised of translucent material.

There were security bars underneath both the skylights and the ceiling vents. These bars measured 0.5 in. (13 mm) in diameter and did not significantly reduce the available area of the ceiling vents.

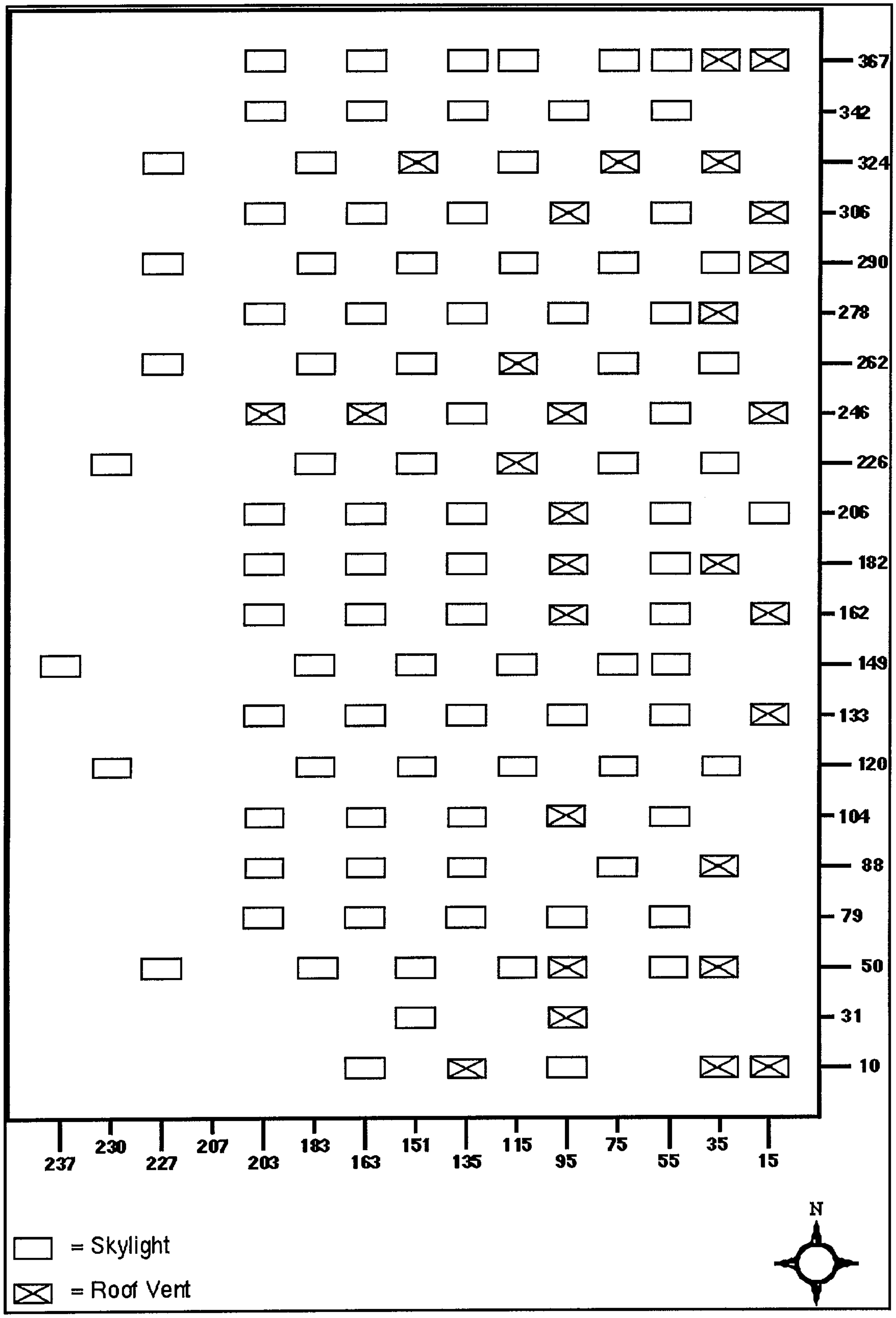


Figure 4

Layout of the roof vents and skylights.

Photo 4. There were a series of draft curtains throughout the store measuring 78 in. (2 m) in depth. One draft curtain was located directly over the aisle where the fire occurred.

Draft Curtains

This facility was equipped with draft curtains at the ceiling level. curtains were spaced 96 ft x 80 ft (29 m x 24 m), creating "cells" measuring 7,680 ft^2 (696 m^2). The draft curtains were constructed of 26 gauge galvanized steel and had a depth of 78 in. (2 m). This resulted in a total volume of 49,920 ft^3 (1,392 m^3). (**See Photo 4**) One draft curtain was located directly over the aisle where the area of origin was located.

Commodities

The store contained a wide variety of material relating to home improvement. In the racks in the area of origin, there was a mixture of items such as plastic patio chairs, seat cushions, patio umbrellas, plastic gas cans, barbecues and barbecue parts, and grass trimmers. These commodities were being stored in corrugated cardboard cartons on shrink-wrapped pallets on the upper levels, and were either loosely displayed or in cartons that had been cut open on the lower levels. Many of these products were Group A, expanded and unexpanded plastics.

The practice was to have items on the lower shelves readily accessible for the public. For example, the seat cushions where the fire started were in a corrugated cardboard box. The front face of the box had been cut away to allow for the cushions to be removed by the customers. In addition, it was reported that some of the products would be placed loose on the shelves. By doing so, this created exposed Group A plastics, as opposed to cartoned Group A plastics.

The upper levels of the rack contained product that was on pallets and was not readily accessible to the customers. Plastic shrink wrap around the four sides of the pallet load was used to stabilize the product.

Commodity List in the Rack of Origin	Patio Chair Pads Umbrellas Table Covers Umbrella Stands Plastic Chairs Plastic Patio Furniture
Commodity List in the Adjacent Rack	Electric Trimmers Gasoline Trimmers Trimmer replacement parts Extension Cords Metal gasoline cans Plastic gasoline cans Trimmer spools
Commodity list in the rack facing the rack of origin	Barbecue grills (assembled) Barbecue grills (unassembled, overstock) Barbecue grill parts and accessories

Fire Protection Systems

The building was protected by three wet-pipe sprinkler systems. The three wet-pipe systems had been designed to provide protection for a Class IV commodity with a storage height of 20 ft (6 m) and a design density of 0.495 gpm/ft^2 over a design area of 2,000 ft^2 (20.2 (L/min)/m^2 over 185.8 m^2) using 286° F (141° C) upright sprinklers with 17/32 in. (13 mm) orifices. Sprinklers were installed at the ceiling level throughout the store and sidewall sprinklers were installed at each steel support column. In-rack sprinklers were installed in a portion of the paint aisle that contained the aerosol paints. The ceiling sprinkler spacing was 8 ft x 9 ft-7 in (2.4 m x 2.9 m), resulting in an area of coverage of 77 ft^2 per sprinkler (7.2 m^2).

The following were the design criteria and the areas of protection for each system. (This information was obtained from the hydraulic nameplates on the risers):

System #1	Area of Protection	Northern Portion of the Structure **Note: Area of Fire Involvement**
	System Demand	1,210 gpm @ 49.7 psi 4,574 L/min @ 343 kPa
System #2	Area of Protection	Southwest Portion of the Structure **Note: System Supplied In-Rack Sprinklers in Paint Aisle**
	System Demand	1,213 gpm @ 47.8 psi 4,585 L/min @ 330 kPa
System #3	Area of Protection	Southeast Portion of the Structure
	System Demand	1,210 gpm @ 49.8 psi 4,574 L/min @ 344 kPa

At the time the building was constructed in 1988, the following water flow data was indicated on the plans:

Static	64 psi	442 kPa
Residual	60 psi	414 kPa
Flow	2,430 gpm	9,185 L/min

The sprinkler systems were installed below a combustible roof deck which had each a 2 in. x 6 in. joist channel filled with a non-combustible foil backed insulation stapled to the bottom of the wood joists. The sprinkler deflectors were located approximately 9 in. (229 mm) below the surface of the foil-backed insulation. This placed the sprinkler deflectors approximately 15 in. (381 mm) below the ceiling/roof deck.

Note: The presence of the foil-backed insulation will be addressed later during the discussion of the system performance.

One-and-one-half in. hose stations were located throughout the facility. The hose stations were supplied from the sprinkler system directly above each station and not from an adjacent sprinkler zone. The fire department connection was located on the front (east) wall of the building near the southern end of the facility.

All three sprinkler systems received water from a single 8 in. (200 mm) water line from the municipal water supply. The 8 in. (200 mm) water supply line was equipped with a double check backflow prevention device. The supply was taken from the underground main on the south-west corner of the structure.

Fire extinguishers

There were portable, manually operated, dry chemical fire extinguishers located throughout the store. These varied from 10 lb to 17 lb (4.5 kg to 7.7 kg) extinguishers.

Fire Alarm System

The fire alarm system monitored the water flow devices on the sprinkler risers. There were visual warning devices located in the rest rooms. There were no audible or visual warning devices located in the general retail area of the store. Upon activation of the alarm system, a signal would be transmitted to a monitoring company located in Texas.

Means of Egress

There were 14 exterior doors that served as exits from the building. These were a combination of conventional, side hinged, manually operated doors and power operated, "break-away" style doors. The total combined width of all of these doors was 1,344 in. (34 m).

Building Occupants

The store was occupied by approximately 60 employees and 50 customers at the time of the fire. Inventory was being taken on the day of the fire, so the number of employees was above normal for this time of day.

Fire Department

The Tempe Fire Department (TFD) is a career fire department with a total of 154 members located in five stations.

TFD provides service to a community 158,000 people spread over 40 square miles. In 1997 they responded to a total of 12,783 calls (both EMS and fire). TFD has automatic aid agreements with several communities that surround it (Phoenix, Chandler, Mesa and Guadalupe), so the closest units are dispatched irregardless of the municipality in which the incident originated.

Inspection and Fire Incident History

According to records provided by TFD, a series of inspections since 1993 of the bulk retail store resulted in citations for blocked exits, secured exits, blocked aisle ways, and obstructions in front of the fire department connections. On July 17, 1995, a fire occurred involving a chemical reaction between pool chemicals, flammable liquids, and weed killer that were stored together in the returns area of the building that was not normally accessible by the customers. The fire was controlled by the first responding engine company and resulted in $5,500 in damage.

Weather

Temperature	75°F	24°C
Winds	Out of the south at 3 to 5 mph	5 to 8 k/hr
Humidity	16%	
Dew Point	27°F	-3°C

III. THE FIRE

Discovery and Occupant Activities

At approximately 4:00 p.m. on Thursday, March 19, 1998, a juvenile ran up to a store employee at the returns desk, which was located near the front of the store. He reported seeing a fire in one of the racks and pointed down one of the aisles. The employee turned towards the area and could see, from approximately 25 ft (8 m) away, a body of fire at about chest height in the rack in the vicinity of the chair cushions. When she first saw the fire, she characterized it as being about the size of a computer monitor.

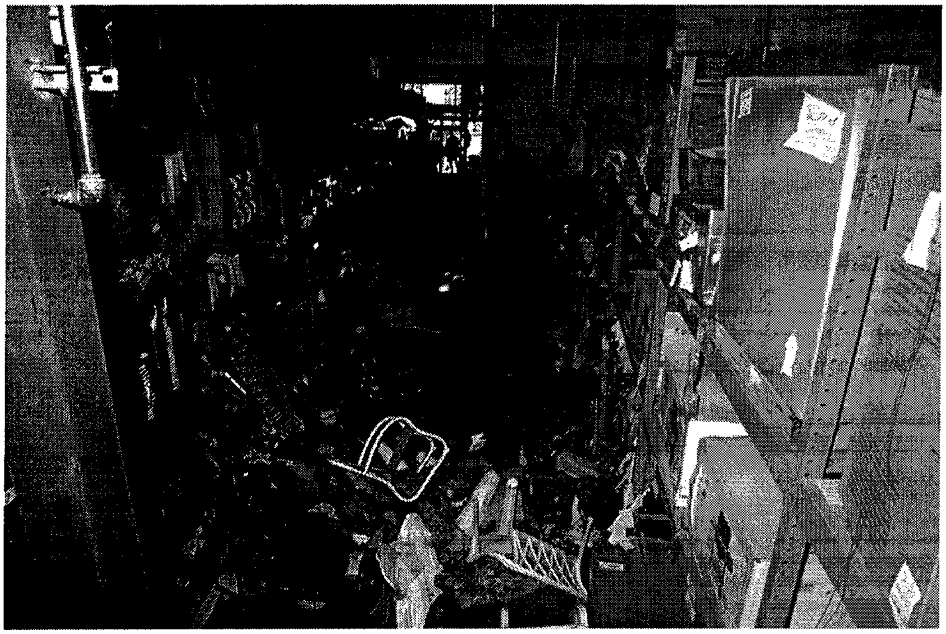


Photo 5. A view of the aisle of origin, looking towards the east. In the background is the returns desk where the first employee to see the fire was located.

The employee turned away from the fire and made a "Code Alexander" announcement over the store public address system. This was a code used to report a serious problem at the front of the store. She realized, however, by the time management responded to the front of the store it would be too late. She then announced over the public address system that there was a fire and everyone should evacuate. She then moved towards the entrance to help people evacuate the store. When she turned back and faced the rack that was on fire, she reported it had now spread up the exposed face of the rack all the way to the top. Statements by other employees corroborated the rapid fire and smoke development.

Fire Department Notification and Response

The Phoenix Fire Department Alarm Room, which serves as the fire communications center for a number of cities, including Tempe, began receiving phone calls reporting a fire in the store at 4:07 p.m. One of the initial calls was from an off-duty Phoenix fire fighter who was shopping in the plaza, and reported the fire to be progressing rapidly and suggested that a first-alarm assignment be dispatched immediately. Several other calls were received in the minutes that followed, all reporting a serious fire. The initial reports were a fire in the paint area.

A first-alarm assignment was dispatched at 4:07 p.m., consisting of:

Phoenix Engine 38 (E38)
Tempe Engine 274 (E274)
Tempe Scene Support 274 (SS274)
Tempe Engine 273 (E273
Tempe Ladder 273 (L273)
Tempe Engine 272 (E272)
Tempe Ladder 271 (L271)
Tempe Ladder Tender 271 (LT271) Guadalupe Engine 241 (E241)
Chandler Engine 284 (E284)
Chandler Ladder 283 (E283)
Tempe Battalion Chief 271 (BC271), Chandler Battalion Chief 281 (BC281), and Phoenix Battalion Chief 5 (BC 5)

The store's central station alarm service received a water flow alarm, and notified the alarm room of a fire alarm from the store at 4:09 p.m.

During the response, the captain from E38 reported seeing smoke rising from the shopping plaza. (Station 38 is located 1.2 miles away from the store.) Upon arrival, E38 reported a working fire and laid a supply line from a hydrant at the northeast corner of the building and proceeded to the main entrance of the store (northeast). The E38 officer assumed command of the incident at this point. The captain conferred with a store manager who indicated that all customers and employees had evacuated the store. It was also indicated that the fire was in the area of the paint aisle, which was directly in front of the entrance.

The E38 captain and one fire fighter advanced an 1-3/4 in. preconnected handline to the front door of the store and prepared to advance into the store. They reported the smoke to be very heavy and was down to the floor level. Prior to entering the building, E38 passed command to the arriving officer on E241.

As the E38 crew began to enter the store, they reported visibility to be limited to 2 ft to 3 ft (0.6 m to 1 m). The automatic opening doors at this entrance were cycling once the crew had entered the store and were closing upon their hoseline. The doors were eventually blocked open and then subsequently removed to facilitate access.

The E38 crew advanced approximately 40 ft into the building and reported moderate heat conditions and continued poor visibility. As they advanced, the crew encountered debris both on the floor and falling around them. They also indicated that the automatic sprinklers were operating, as they could sense water from the sprinklers discharging on them.

They reported now being close enough to see a glow within the storage racks in front of them. They directed their hose stream into this area for approximately 10 minutes before exiting the building to report on interior conditions and to replace their air bottles. Upon exiting the E38 captain reported on interior conditions to a Tempe battalion chief who had arrived on the scene and been assigned to the interior sector. After replacing their SCBA air bottles, the E38 crew entered once again with the BC.

E274 arrived at approximately 4:11 p.m. and was instructed to proceed to the northwest corner of the building, connect to the hydrant at that location, and then enter the building at that side. Three fire fighters from this unit advanced a preconnected 1-3/4 in. handline to the west gate of the outdoor garden center. Before this, attempts were made to enter at the loading dock at the northwest corner of the building. However, all of the overhead-type dock doors were found secured. The crew also found all of the outer gates of the garden center to be inaccessible from the exterior. Eventually an employee with a key was located and the garden center gate was opened.

The crew then advanced the hoseline into the store with two fire fighters on the line while the third advanced the hose around the numerous obstacles they were encountering in the garden center. The crew proceeded south into the store toward the seat of the fire. They reported a heavy smoke condition and near zero visibility. This crew also encountered debris while advancing in the building and reported the operation of automatic sprinklers. They advanced to the end of the racks perpendicular to the area of origin and operated their handline onto visible fire until their breathing apparatus alarms sounded. They then exited the building.

E241 arrived at approximately 4:14 p.m. and proceeded to the front of the building near where E38 was located. The officer on this unit was asked to assume command upon his arrival. Firefighters from this unit pulled another 1 3/4 in. handline from E38 and advanced to the entrance where E38 first gained access. The two fire fighters from E241 then assisted the E38 crew on the first handline before exiting the building. The fire fighters from E38 replenished their air bottles and then reentered the building to operate the first handline. The crew from E241 assisted a crew from E277, dispatched on the second alarm, advance the second handline into the same area.

E273 arrived at approximately 4:15 p.m. and proceeded to the hydrant at the northeast corner of the building where E38 had connected a supply line. Through a hydrant-assist valve, E273 supplied E38 from this position. The crew from this unit was then assigned to disconnect the utilities to the building.

L273 arrived at approximately 4:16 p.m. and was instructed to access the roof and begin ventilation operations. The truck was placed at the southeast corner of the building and the ladder was raised to the roof. (All responding crews when later interviewed reported smoke issuing from rooftop vents upon arrival of the first units.) The crew from L273 indicated that four vents were open as they reached the roof. It was subsequently determined that one skylight, directly over the fire, had burned through and three automatic ceiling vents had opened. The crew proceeded to open another six vents in the area of the fire. In addition, another 42 vents were opened by sawing through the rigid fiberglass covering or by popping open the ceiling vents where the links had fused, but the vents had not opened. Eventually, the crew exited the roof to refuel the saw and replenish their breathing apparatus bottles. They returned to the roof with the crew from L204, which responded on the second alarm, and continued to open roof vents to assist in the evacuation of smoke.

E272 arrived at approximately 4:19 p.m. This unit was originally ordered by the officer from E241 to proceed to the fire department connection and prepare to further supply the sprinkler system. This order was changed by one of the battalion chiefs (BC). The BC was preparing for a possible defensive attack and ordered the unit, which was equipped with a 50 ft aerial ladder with pre-piped waterway, to the northwest corner of the building to prepare for ladder pipe operation, should it become necessary. From their location in the northwest portion of the store, E272 assisted E274 with suppression and primary search operations.

At 4:22 p.m. E284 was ordered to connect to the sprinkler system.

A second alarm was requested at 4:26 p.m. The following units responded on this alarm:

- Tempe Engine 277 (E277)
- Tempe Engine 271 (E271)
- Chandler Engine 282 (E282)
- Chandler Engine 286 (E286)
- Chandler Engine 283 (E283)
- Chandler Ladder 281 (L281)
- Chandler Ladder Tender 281 (LT281)
- Phoenix Engine 705 (E705)
- Mesa Engine 207 (E207)
- Mesa Ladder 204 (L204)
- Mesa Ladder Tender 204 (LT204)
- Mesa Utility 204 (U204)
- Gilbert Ladder 251 (L251)
- Phoenix Engine 14 (E14)
- Phoenix Loss Control 14 (LC14)
- Mesa Battalion Chief 201 (BC201)
- Laveen Battalion Chief 111 (BC111).

These incoming units were staged at Warner and Kyrene Streets (second-level staging).

A request was made at 4:45 p.m. for a police helicopter that was equipped with a Forward Looking Infrared (FLIR) unit to assist in locating hidden fire within the building. However, this unit was not available.

During suppression operations, interior units reported that pesticides and other garden-type chemicals were involved. A gross decontamination station was established by E271 at the northeast entrance to the store at approximately 5:05 p.m.

Accountability stations were established by incoming units at each entrance being utilized by crews to track firefighters entering and exiting the building. The incident command system was established with the first incoming units and continued throughout the incident, expanding as the incident grew in size. The first arriving unit (E38) assumed command and then passed command to E241 as the E38 crew entered the building. A battalion chief from Tempe took command from the officer from E241 after a "face-to-face" conference.

Once the main body of fire was reported "knocked down," the extensive overhaul operations began. All units interviewed reported merchandise falling from the storage racks during both suppression and overhaul operations. Extreme care was taken by all units operating inside the building to watch for the potential of falling debris and merchandise.

The sprinkler systems within the building were shut down by E277 at 5:45 p.m. This unit stayed in the sprinkler room to monitor the sprinkler system risers in the event the sprinkler system had to be turned back on. Personnel from E277 reported that the pressure gauges on the risers were indicating approximately 100 psi to 125 psi (690 kPa to 862 kPa) of water pressure prior to the system being shut down.

Smoke removal proved difficult due to the size of the building, the height of the ceilings, and the large amount of smoke generated during the fire. Positive pressure fans were set up at the main entrance of the store, while openings around the perimeter of the building were controlled. A large blower fan operated by the Phoenix Fire Department was requested. However, this unit was unavailable. Eventually the smoke lifted and was removed from the building to further facilitate overhaul operations.

An occupant services sector was established to assist the owners of the other stores in the plaza who were impacted by the fire.

A rehabilitation sector was established early into the incident. All units eventually were sent through this area prior to being reassigned or returned to service. Units began leaving the scene at approximately 6:45 p.m. The scene was secured at 9:13 p.m. as the remaining units left the scene.

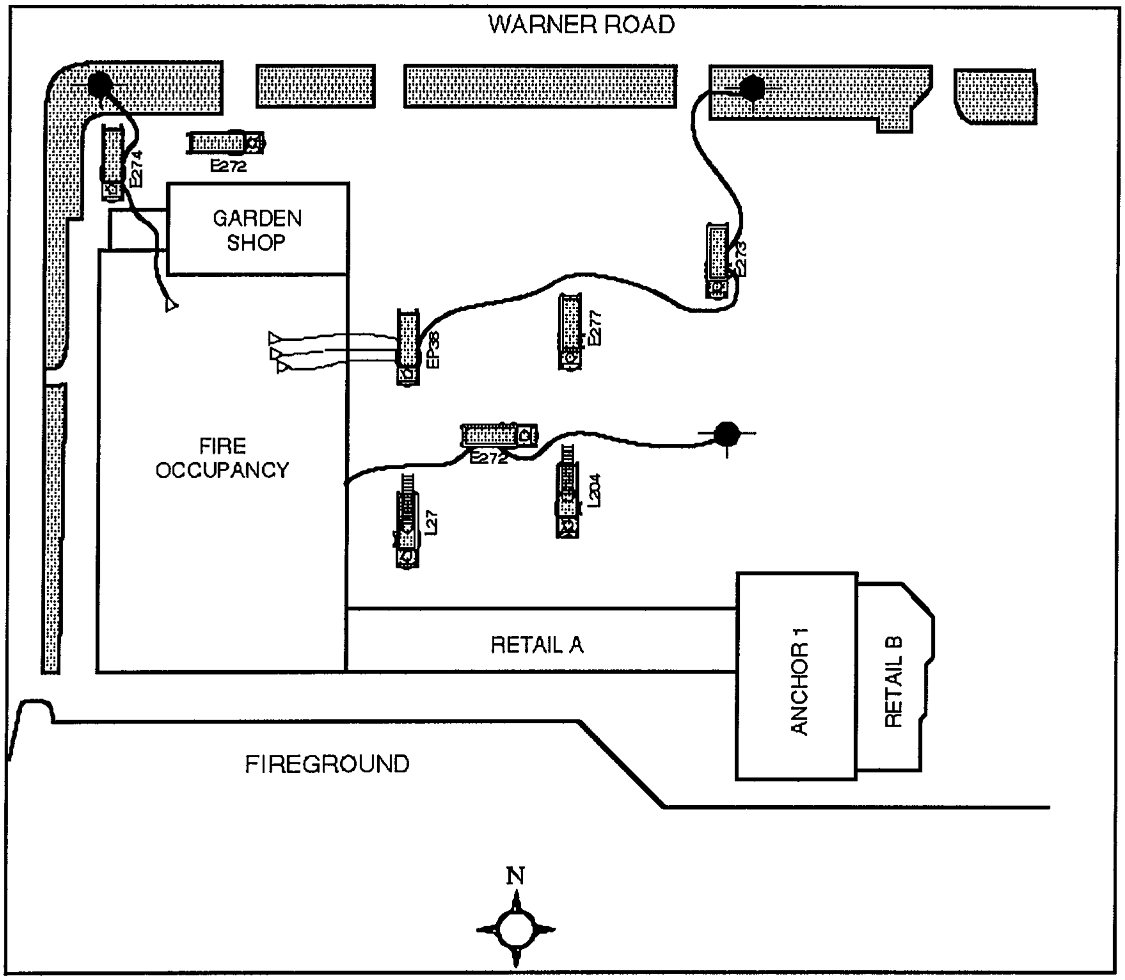


Figure 5 Location of apparatus during fire fighting operations

Casualties

There were no injuries or fatalities as a result of this fire.

DAMAGE

Product

The fire damaged an area of approximately 1,500 ft^2 (139.4 m^2). All of the product within this area was totally destroyed or seriously damaged.

Shelving/Racks

Approximately 96 ft (29 m) of racks had to be replaced.

Structure

Two trusses had to be replaced. A third truss had a new one placed next to it to reinforce it. A number of roof panels directly over the fire had to be replaced. A number of skylights had to be replaced.

Business Interruption

The store reopened on Friday, March 27, seven days after the fire. Damages, including business interruption, were estimated to be $6,000,000.

IV. TIMELINE

4:06 p.m.	First telephone call received
4:07 p.m.	First alarm assignment dispatched
4:09 p.m.	Alarm company called in alarm
4:11 p.m.	Engine 38 on the scene, reported a working fire and assumed command
4:11 p.m.	Engine 274 on the scene
4:14 p.m.	Engine 241 on the scene
4:15 p.m.	Engine 273 on the scene
4:15 p.m.	Ladder 283 on the scene
4:15 p.m.	Engine 284 on the scene
4:16 p.m.	Command transferred from Engine 38 to Engine 241
4:16 p.m.	Ladder 273 on the scene
4:17 p.m.	Battalion 271 on the scene, command transferred from Engine 241
4:18 p.m.	Engine 272 on the scene
4:18 p.m.	Engine 273 on the scene
4:20 p.m.	Ladder 271 on the scene
4:22 p.m.	Engine 284 to pump the sprinkler system
4:23 p.m.	Battalion 5 on the scene
4:25 p.m.	Battalion 281 on the scene
4:26 p.m.	Second alarm dispatched
4:27 p.m.	Car 957 (Safety) on the scene
4:29 p.m.	Engine 705 on the scene
4:29 p.m.	Battalion 1 on the scene
4:30 p.m.	Battalion Chief Bailey assumes interior sector
4:37 p.m.	Utility 1 on the scene
4:37 p.m.	Engine 277 on the scene
4:38 p.m.	Rehab 10 on the scene
4:38 p.m.	Engine 705 on the scene
4:38 p.m.	Ladder 283 on the scene
4:39 p.m.	Engine 284 reports that they have charged the sprinkler system and crew is available for reassignment
4:40 p.m.	Command Van 1 on the scene
4:41 p.m.	Engines 207 and 282 staged
4:42 p.m.	Interior is reporting a lot of smoke, to the floor, a lot of high piled stock that has fallen into the aisle; still have not found the seat of the fire....have not been able to get an all clear yet.
4:42 p.m.	Ladder 271 on the scene
4:46 p.m.	Ladder 204 in staging
4:53 p.m.	Engine 14 staged
4:56 p.m.	Utility 204 staged
4:56 p.m.	Battalion 201 staged
4:58 p.m.	Engine 271 on the scene
5:17 p.m.	Engine 282 on the scene
5:43 p.m.	Sprinklers shut down by Engine 277
10:12 p.m.	Incident closed

V. ANALYSIS

Cause and Origin

The origin of the fire was determined by the Tempe Fire Department to be in the lower portion of a 15 ft (4.6 m) high rack approximately 5 ft (1.5 m) above the floor. The material first ignited was probably seat cushions, which would have been classified as Group A expanded plastics. The source of ignition was butane lighters that were on sale in the area. There was no evidence of accelerants used. It was declared incendiary in nature.

Fire Growth and Spread

After the cushions were ignited by the lighters, the fire then proceeded to spread both laterally and vertically. According to the eyewitnesses, the fire grew very rapidly, spreading from a height of approximately 5 ft (1.5 m) to the top of the 15 ft (4.5 m) rack within several minutes.

The fire also spread laterally, east and west, within the rack for a distance of 32 ft. It proceeded to ignite material in the rack immediately adjacent to it

Photo 6. The rack of origin. It was determined that the fire was started by juveniles using lighters that were on display. They ignited seat cushions.

(to the north) that was separated by a flue space. The products in this rack, which were composed of grass trimmers and plastic gasoline cans, were also destroyed for a length of 32 ft and the full height of the rack.

The fire jumped the 10 ft (3 m) aisle from the rack of origin and ignited the products being stored on another rack. These products included gas grill components packaged in plastic and cardboard material.

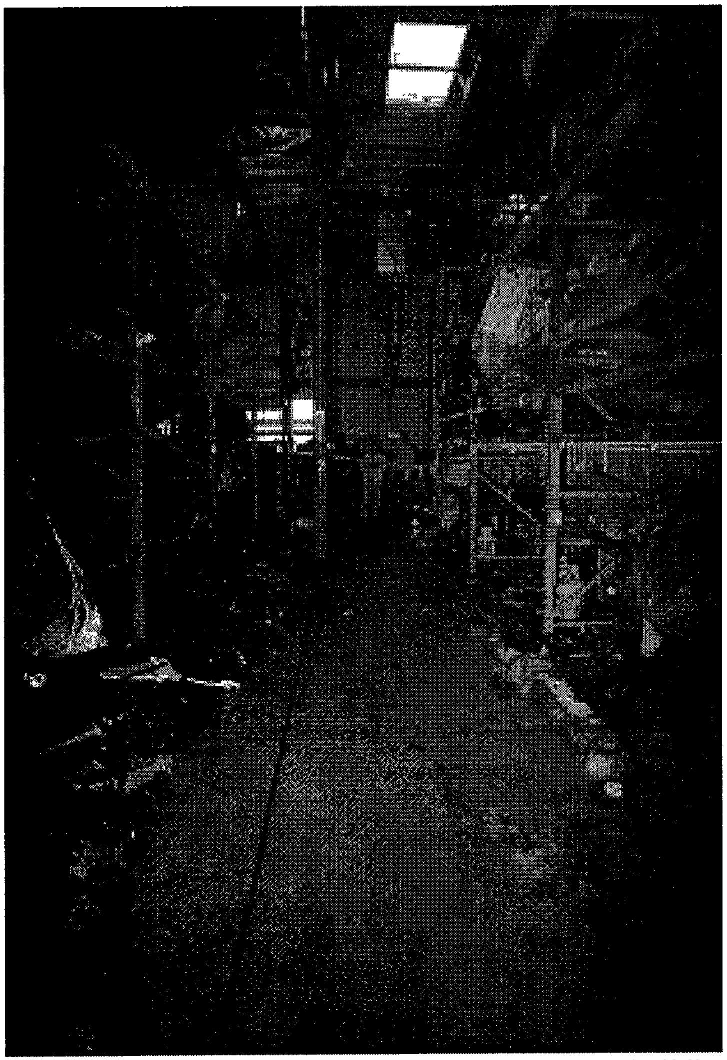


Photo 7. A view of the aisle of origin, looking east towards the Returns Desk. The fire jumped across this 10 ft (3 m) aisle, from left to right, igniting the products on display.

The fire spread upward towards the roof support trusses, damaging three of them. Two trusses and a number of the roof panels had to be replaced. The third truss had a new truss assembly installed next to it to provide additional support.

Eyewitnesses report that there was rapid smoke development from this fire. As the first fire department unit was responding, they could see heavy smoke showing from approximately one mile away. Upon arrival, they reported that the entire height of the building was filled with smoke in the portion of the building where the fire occurred.

Fire Protection Systems - Operation

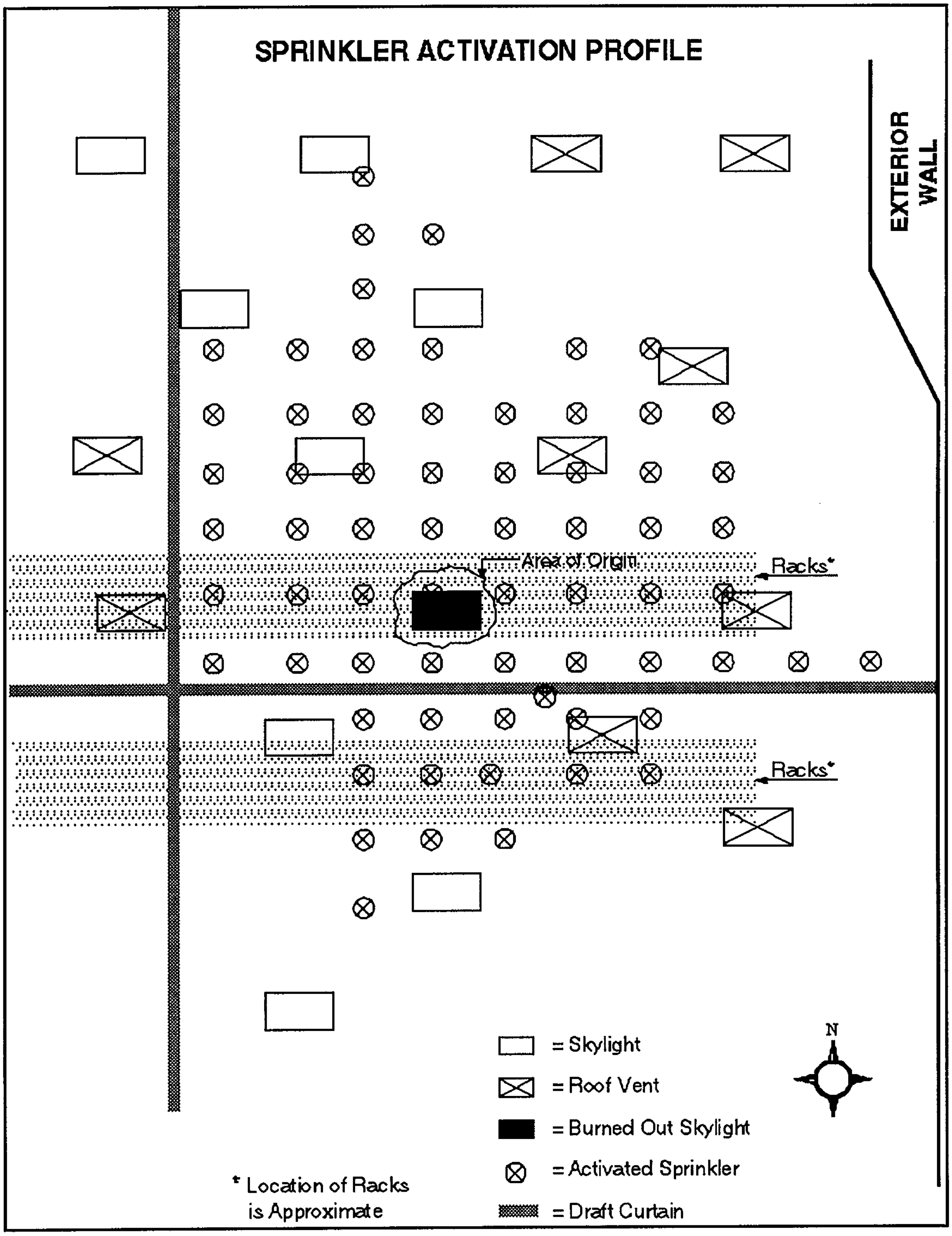
Fire Sprinkler Systems

It was determined that sprinkler system #1 had 67 sprinklers operate during the fire. Of these 67, one sprinkler was installed adjacent to one of the structural columns and provided additional protection to the column. Sprinkler activation occurred on both sides of the draft curtain that was located in the aisle between Rack #1 and Rack #2. Twelve sprinklers operated to the south of the draft curtain and the remaining (54) sprinklers operated to the north of the draft curtain. The number of sprinklers that operated covered 5,082 ft^2 (472.1 m^2) and was in excess of the anticipated design area of 2,000 ft^2 (185.8 m^2).

Heat Vent Performance

A skylight directly over the fire had burned out and three heat vents had automatically opened upon fire department arrival. An additional 42 vents and skylights were either manually opened or cut open by the fire department during fire-fighting operations. Fire department personnel reported that a number of the ceiling heat vents' thermal elements had fused, but these vents did not open. The heat vents that had not properly operated were forcibly opened by the fire fighters.

Figure 6. Location of the fire in relation to the draft curtains, roof vents, skylights and the sprinklers that activated.



Draft Curtains

A draft curtain was located directly over the aisle of origin. The rack of origin was located approximately 5 ft (1.5 m) to the north of this curtain. A total of 66 ceiling-level sprinklers activated in this fire, 52 of which were located to the north of the draft curtain. The fire leapt the aisle, traveling underneath the draft curtain, and ignited the rack to the south of the draft curtain on fire. Another 12 ceiling-level sprinklers and one column sprinkler activated on the south side of the draft curtain over this second rack.

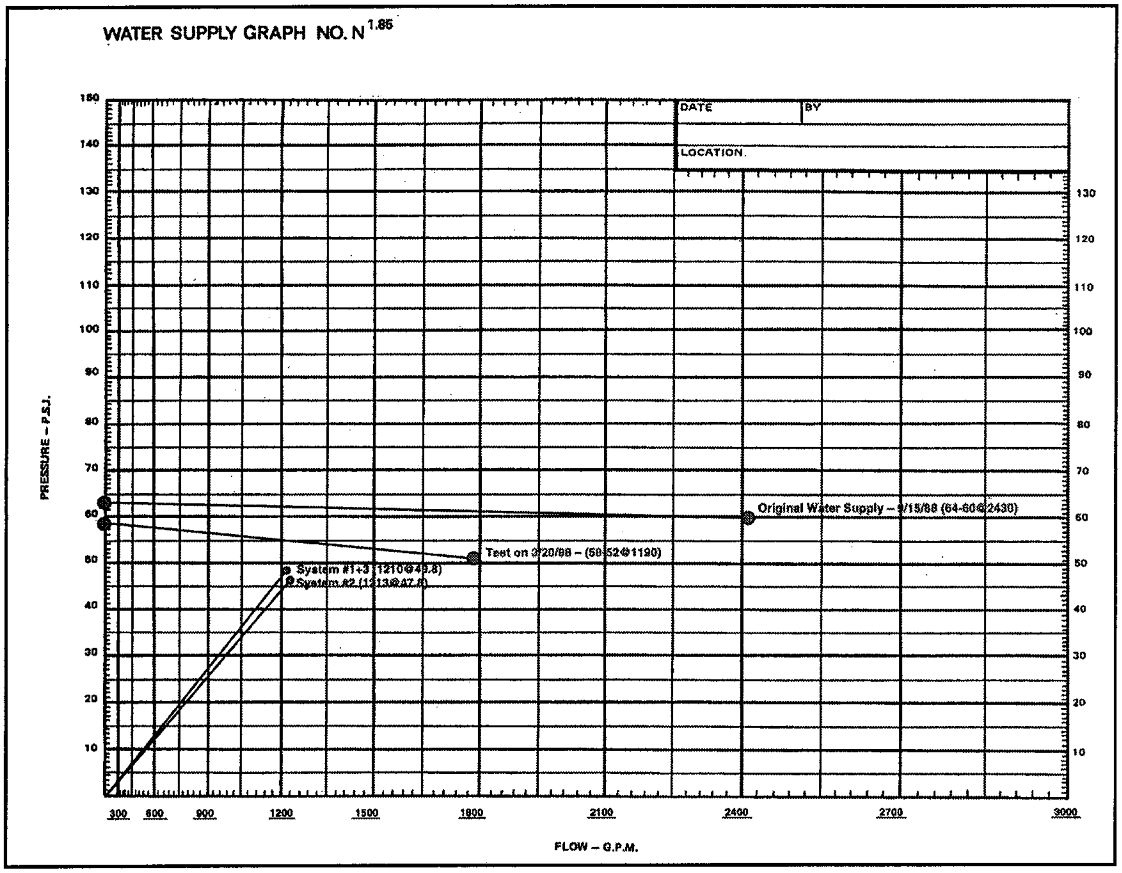
Water Supply

A water supply test performed the day after the fire had the following results:

Static Pressure	58 psi	400 kPa
Residual Pressure	52 psi	358 kPa
Flow	1,190 gpm	4,504 L/min

Based upon fire department statements, the pressure on the sprinkler systems was 100-125 psi (690 kPa to 862 kPa) at the sprinkler riser room during fire-fighting operations. The increased pressure on the sprinkler system was a result of fire department supplementing the water supply through the fire department connection.

Figure 8 Water supply curve showing the water supply prior to, and following, the fire.



Investigators observed that in a number of areas the foil on the ceiling insulation had fallen down, either during the initial fire development or during fire-fighting operations. This occurred in areas directly involved in the fire and in areas remote from the fire and fire-fighting operations. In some cases, it was draped over sprinklers, which adversely affected the spray pattern from those sprinklers, reducing the overall effectiveness of the sprinkler system in controlling the fire spread.

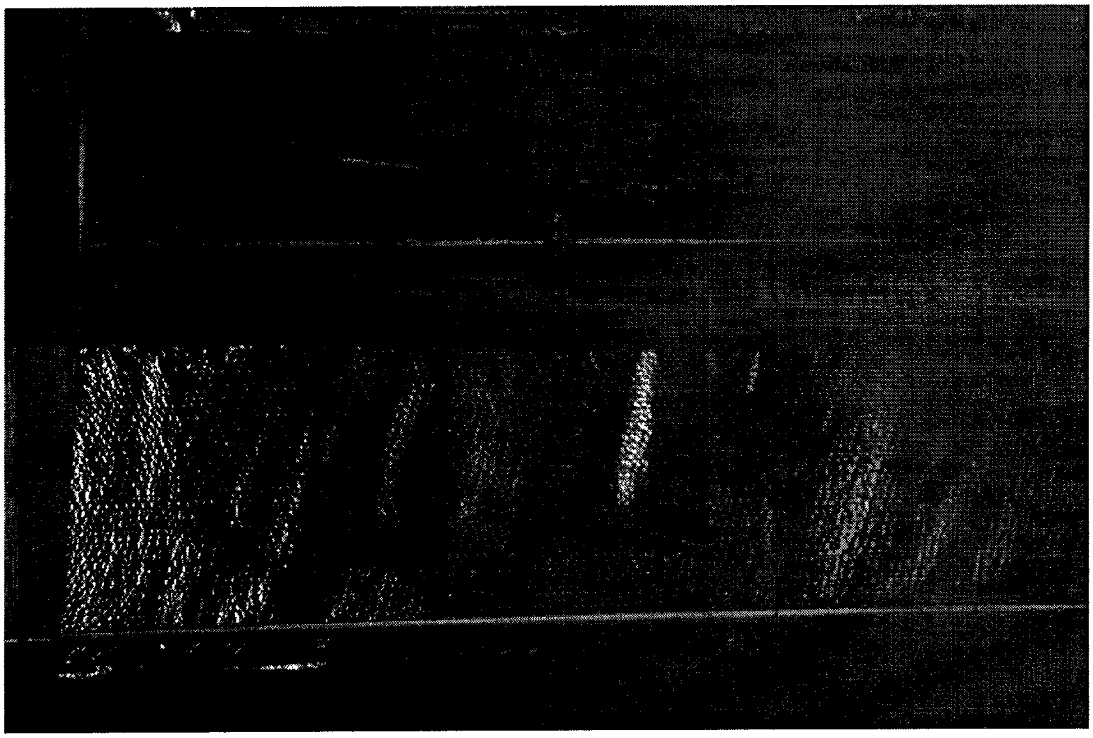


Photo 8. There were a number of locations where the foil from the roof insulation was dislodged and hung down, obstructing the spray from the sprinklers.

VI. DISCUSSION

The following are several factors involved in this incident that contributed to the loss:

Fire ignition through arson	The lighters that were used in igniting the fire were on display and were readily available.
Ceiling sprinkler density	The sprinkler system had been designed for a Class IV commodity when the store was opened. However, at the time of the fire, the commodity that was being protected was primarily Group A, expanded and unexpanded plastic. The level of protection did not match the hazard presented by the commodity. While the inadequately designed sprinkler system certainly played a role in slowing the fire growth and ensuring that it did not completely destroy the building, there are several areas of concern regarding its operation. First, the number of sprinklers that activated exceeded the design area by a factor of 2.5. Secondly, the fire was able to leap across a 10 ft aisle and ignite material stored in that area. NFPA documents address the protection required for Group A plastics, in cartons, in rack storage. A sprinkler density of 0.6 gpm/ft^2 over 4,000 ft^2 (24 $(L/min)/m^2$ over 371.6 m^2) would be required as a minimum. The precise role that the draft curtains and ceiling vents had on the operation of the sprinkler system is unknown. However, the sprinkler protection requirements called for in NFPA documents are not based on the presence of either of these features.
Sprinkler spray pattern	In a number of cases, the foil from the ceiling insulation obstructed the spray pattern on the sprinklers. Sprinkler systems are designed to deliver a specific density of water over a given area. Anything that obstructs their ability to do so will impair their ability to control the fire.

Flue spaces	NFPA 231C requires a minimum of 6 in. (13 mm) of transverse flue space for heights up to 25 ft (7.6 m) to ensure effective sprinkler operation in rack storage configurations. Longitudinal flues are not required for storage up to 25 ft (7.6 m). Due to the practice of installing solid shelving material right up to the rack's vertical members, only three in. of transverse flue space existed. In addition, the practice of storing commodity at the top level over the transverse flue further compounded the obstruction to the transverse flue space.
Draft curtains	Due to the activation profile of the sprinklers, it would appear that the draft curtains had a role in the operating sequence of the sprinklers. The impact that they had is a case for further study to determine the value of draft curtains in a fire protection scheme.
Fusible links on the ceiling vents	Since the links on the vents were below those of the sprinkler system, they should have opened prior to sprinkler activation. In this case, it was reported that a number of the links had fused, but the vents had not opened. This may have occurred because of the weather caulking that had been applied to the translucent panels. If the ceiling vents had opened, this would have allowed for the release of heat, impacting the activation profile of the sprinklers. There is some debate over the value of having roof vents operate automatically during a fire as opposed to having the fire department open them manually.
Fire alarm system	There were several areas within the store which were enclosed and were not equipped with any type of warning devices. One area in particular, the computer room, was of concern to a number of employees during the fire because they were afraid that the people working in that room may not be aware of the fire. One employee took the time to call the room to ensure that they were aware of the fire, but the telephone line was busy and she was not able to get through.

VII. CONCLUSION

The level of protection being provided in bulk retail stores is a matter of concern for many local fire and building officials. This is the third fire that NFPA has investigated in one of these occupancies within three years. While the other two involved oxidizers (pool chemicals), which greatly accelerated the fire, this fire involved commonly available, conventional fuel loads.

In all three fires there have been no deaths. However, considering the potential number of customers that can be in one of these stores and the speed with which this particular fire grew, there is a concern over the potential risks. There is also a strong concern for the fire fighters that must attack fires in these buildings. Due to the nature of the business, there are very wide and varied commodities being sold in these buildings. Some of these products, such as pesticides, herbicides, oxidizers, flammable and combustible liquids, and aerosols, can present significant hazards to fire fighters. The additional risk of product that is stored on pallets on the upper shelves dropping during interior fire-fighting operations creates another serious hazard that must be addressed during fire attack.

NFPA documents address many of the conditions that were observed at this fire. By applying these documents, utilizing proper engineering judgment, and having an ongoing program of inspection and maintenance of conditions with these stores, the level of risk can be significantly reduced.

APPENDIX A. NFPA CODE REFERENCES

The following are several NFPA documents that relate to the fire protection requirements for this type of occupancy.

NFPA 1	**Fire Prevention Code**	This is a document that encompasses many recommended fire protection practices in areas such as building design, fire protection requirements, exit design, fire requirements, etc.
NFPA 13	**Standard for the Installation of Sprinkler Systems**	This document addresses many of the technical requirements for the proper design, installation and maintenance of a sprinkler system.
NFPA 13E	**Guide for Fire Department Operations in Properties Protected by Sprinkler and Standpipe Systems**	This guide provides basic suggested procedures and information for fire department operations in properties equipped with certain fixed fire protection systems.
NFPA 101®,	**Life Safety Code®**	This document deals with the requirements for exit design and fire protection needs of buildings. Additional provisions have been made in Chapters 24 and 25 (Existing and New Mercantile Occupancies) to deal with bulk merchandising retail buildings because of the unique fire protection and life safety issues addressed in these occupancies.
NFPA 231C	**Standard for Rack Storage of Material**	This document addresses the requirements for materials that are stored in rack configurations, such as were found in the Tempe Bulk Retail Fire. It covers the sprinkler density requirements and sprinkler placement issues associated with commodity type, storage height, flue openings, aisle width and storage methods.

APPENDIX B

ABSTRACTS FROM RELATED NFPA FIRE INVESTIGATIONS REPORTS

Quincy, Massachusetts

At 8:23 p.m. on Tuesday, May 23, 1995, a four-alarm fire occurred in a bulk merchandising store in Quincy, Massachusetts. At the time of the fire the building was occupied by approximately 60 employees and 100 customers.

The single-story building was of noncombustible construction with an area of 122,395 ft^2. The display merchandise and bulk storage was on a metal double rack system throughout the store. The building was equipped with a fire alarm and sprinkler system.

The fire started in the lower storage rack of an area that stored pool chemicals. An investigation conducted by the Quincy Fire Department and the Massachusetts State Fire Marshal's Office determined the fire was accidental in nature that was probably caused by a chemical reaction involving pool chemicals and leaking motor oil. The motor oil leaked from boxes containing lawn mowers stored in the vicinity of the pool chemicals. The lawn mowers were shipped in containers that included a small quantity of oil that had to be added prior to use.

Based on the NFPA's investigation and analysis of this fire, the following significant factors were considered as having contributed to the loss of property in this incident:

- Incompatible materials stored too close to oxidizers
- Materials stored in excess of allowable storage heights and within 18 in. of the sprinklers
- Inadequate sprinkler design for encapsulated materials
- The lack of in-rack sprinklers
- Rack shelving of solid materials and wooden slats spaced too close together
- Storage in aisles, which reduced commodity clearance between adjacent racks

Albany, Georgia

At approximately 11:21 a.m. on Tuesday, April 16, 1996, a fire occurred at a fully sprinklered bulk retail store in Albany, Georgia. Arriving fire fighters found the fire beginning to vent through the roof and through an area where the walls had begun to separate. Despite the fire fighters' efforts, the rapidly growing fire spread through the entire building destroying it and all the merchandise inside. The loss had been estimated at $9,000,000.

This facility was a bulk retail store providing home improvement products such as lumber, plumbing supplies, electrical supplies, tools, garden supplies, etc. Oxidizers in the form of pool chemicals were among the many products sold by this bulk retailer.

The three-year-old, single-story, noncombustible, 85,000 ft^2 (7,900 m^2) building was protected by three wet-pipe sprinkler systems. The facility also had a dry-pipe sprinkler system that protected the garden center. Portable dry chemical fire extinguishers, manual fire alarm boxes, and a fire alarm system were among the other fire protection equipment provided. Staff members were trained regarding their response to fire and other emergencies.

Fire department investigators determined that the fire began in the area where the pool chemicals were stored. The cause of the fire was not determined. Once ignited, the fire spread through the rack containing the pool chemicals. The fire produced large amounts of irritating smoke causing conditions in the building to deteriorate rapidly. The building's estimated 100 employees and 85 customers safely evacuated the store before fire fighters arrived.

The rapidly growing fire appears to have overwhelmed the building's sprinkler systems, and fire conditions upon their arrival prohibited fire fighters from performing interior fire-fighting operations. As a result, the fire spread from one end of the building to the other, causing the entire roof to collapse. All of the building's contents were consumed.

The NFPA's investigation of the April 16, 1996, fire in Albany, Georgia, revealed the following deviations from current NFPA code requirements:

- The storage of oxidizers on racks that exceeded height and depth limits for retail storage
- The lack of solid, noncombustible vertical barriers between oxidizers and incompatible materials
- The lack of in-rack sprinklers for the area protecting the oxidizer storage
- Sprinkler systems that were designed to discharge densities and areas of operation that were below current NFPA requirements for oxidizer storage

Based on the NFPA analysis of this incident, these deviations from NFPA codes contributed to the severity of the fire and to the loss of property.

NATIONAL FIRE PROTECTION ASSOCIATION
FIRE INVESTIGATIONS DEPARTMENT
1 BATTERYMARCH PARK
QUINCY, MA 02269 USA
(617) 984-7467 (TEL)
(617) 984-7056 (FAX)
EMAIL: INVESTIGATIONS@NFPA.ORG
WWW.NFPA.ORG/INVESTIGATIONS.HTML

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EMAIL: LIBRARY@NFPA.ORG
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